RECTANGULAR AND SQUARE DOUBLE WALL DUCTING SYSTEMS

CROSS-REFERENCE(S) TO RELATED APPLICATION(S)

The present application claims the benefit of U.S. Application Serial Nos. 60/395,543 filed July 11, 2002, and 10/359,017 filed February 3, 2003.

FIELD OF THE INVENTION

The present invention relates to rectangular and square double wall heating, ventilating and air conditioning (HVAC) ducting and methods of making and interconnecting such ducting.

BACKGROUND OF THE INVENTION

Square and rectangular ducting are widely used in HVAC systems. Such ducting can be located between floor or ceiling joists whereas ducting of other cross-sectional shapes, such as round, may not fit in such locations and still be sufficiently large enough in size to handle the HVAC load required.

Referring to Figures 1-3, it is known to manufacture square and rectangular single wall ducting structures such as structure 20, by bending a sheet of thin-gauge material to form the corners and the four walls of a length of ducting 22 and then join the duct together along one corner 24 to form an integral structure. This corner joint may take various forms, such as by overlapping portions of the ducting and then screwing the overlapped portions together, or by utilizing an "S" shaped flange 26 or other shaped

member to join the ducting along corner 24. Typically, lengths of square and rectangular ducting produced in this manner are relatively limited in length due to the size of the brake press or other machinery used to form the corners of the ducting and also limited by the length of the sheet metal stock available.

Because square and rectangular cross-section HVAC ducting is typically of relatively short lengths, it is necessary to connect ducting sections end-to-end to achieve a desired overall length. In this regard, as shown most clearly in FIGURES 1 and 2, a face flange structure 28 is integrally formed at the ends of each wall of the duct 22. The face flange structure has a mating or face section 30 extending perpendicularly to the corresponding wall of duct 22 and a reinforcement hem structure 32 extending transversely from the distal edge flange face 30. The hem structure 32 may be folded over on itself to form a double thick section for additional strength. In FIGURE 1, the hem structure 32 is folded inwardly on itself whereas in FIGURE 2, the hem section is folded outwardly on itself.

As will be appreciated by the foregoing construction, it is not possible to extend the face flanges 28 to occupy the entire corner at the juncture between two adjacent panels of the ducting structure 20. Such open corners are "filled in" by an angle bracket 34 that typically nests with the adjacent portions of the face flange structures 28. FIGURE 1 shows the angle brackets 34 prior to installation, whereas FIGURE 2 illustrates the angle flanges in installed positions. The angle flanges include corner apertures 35 for receiving a hardware fastener 36 therethrough. The hardware fastener may be in the form of a threaded screw that mates with a nut 38. In this manner, the face flange structures 28 are connected together in face-to-face relationship at the corners of the ducting structure 20. A flat or other shaped gasket 40 may be interposed between adjacent flange faces 30 in an effort to provide an airtight seal therebetween.

However, a sufficient seal usually is not achieved through the use of only the angle brackets 34. As such, typically formed clips 40 are used to also retain the adjacent face flange structures 28 together in an engaged face-to-face relationship. As shown in

FIGURE 2, the clip 40 is shaped and sized to wrap around the reinforcement hem structures 32 of the face flange structures 28.

Referring to FIGURE 3, typically reinforcing members are needed to increase the structural integrity of ducting sections 20 and to prevent the ducting sections from unduly vibrating. FIGURE 3 illustrates such reinforcing members in the form of "Z" brackets 42 that extend transversely across duct 22, with one of the flange sections of the brackets attached to the duct by hardware members, welding or otherwise.

It can be appreciated that the prior art single wall ducting structure shown in FIGURES 1-3 is time-consuming and expensive not only to fabricate, but also to assemble and install in the field. The present invention is directed to economical and rapid methods for manufacturing, assembling and installing HVAC double wall ducting of a rectangular or square cross-section.

SUMMARY OF THE INVENTION

A ducting structure of a square or rectangular cross-section is formed from round duct sections that are transformed into square or rectangular cross-sections by an expansion apparatus composed die structures of structures that press against the interior of the round cross-sectional ducts to force the ducts to assume a desired square or rectangular cross-sectional shape.

The square or rectangular cross-sectional duct sections are inner-connected by formed flanged connectors that may be of numerous possible profiles. Each of the flanged connectors does include outer and inner insertion sections that engage into, or over, the adjacent end portions of the outer and inner duct sections, and outer and inner mating flange sections extending substantially perpendicularly to their respective insertion sections to form a mating surface for face-to-face engagement with the flanged connector of the adjacent duct section. Preferably, but optionally, a re-enforcing section is disposed at the outer perimeter portions of the mating flanges. The re-enforcing sections may be of numerous configurations. The outer reinforcing section may include a

hem section that extends outwardly from the outer mating flange and also optionally a return section to enhance the structural integrity and stiffness of the re-enforcing section.

The flanged connectors are formed from strip stock that is notched at it ends and also at other locations along its length to define the location of the corners of the flanged connector. The desired cross-sectional profiles of the outer and inner flanged connector positions are formed into the strip stock by roll forming, bending, or other well-known processes. Thereafter, the partially formed strip stock is bent at the notch locations to form the corners of the rectangular or square shaped flanged connector portions. The free ends of the strip stock are then affixed together to form a rigid structure. The inner and outer flanged connector portions are then joined together so that their respective mating flange portions are in alignment so as to form a substantially planar combined mating flange. The thus-formed flanged connector can be attached to the end of a double wall duct section so that adjacent double wall duct sections can be coupled together.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a fragmentary view of the corner portions of a prior art ducting structure;

FIGURE 2 is another fragmentary view of prior art ducting structure;

FIGURE 3 is a pictorial view of a prior art ducting structure corresponding to FIGURES 1 and 2;

FIGURE 4 is a cross-sectional view of a round pre-formed duct;

FIGURE 5 is a cross-sectional view of the round cross-sectional duct engaged over an expansion apparatus;

FIGURE 6 is a cross-sectional view of a duct section after being transformed by an expansion apparatus from a round cross-section;

FIGURE 7 is an alternative embodiment of an expansion apparatus;

FIGURE 8 is a cross-sectional view of a duct after transformation by the apparatus of FIGURE 7;

FIGURE 9 is fragmentary view of an embodiment of a single wall duct structure of the present invention illustrating a formed flanged connector ring engaged with an end portion of duct of rectangular cross-section, with portions broken away for clarity;

FIGURE 10 is planned view of strip stock utilized to form a flanged connector;

FIGURE 11 is an alternative embodiment of strip stock shown in FIGURE 10;

FIGURE 12 is a further alternative of the embodiment of the strip stock shown in FIGURE 10;

FIGURE 13 is a plan view of the strip stock of FIGURE 10, after being partially formed by roll forming and/or other manufacturing techniques;

FIGURE 14 illustrates a pair of flanged connectors corresponding to FIGURE 9, shown in face-to-face relationship;

FIGURE 15 is an alternative embodiment of flanged connectors constructed in accordance with the present invention shown in face-to-face relationship;

FIGURES 16, 17, and 18, are alternative embodiments of flanged connectors shown in face-to-face relationship;

FIGURE 19 illustrates one of the steps in roll forming flanged connectors according to the present invention;

FIGURE 20 is a cross-sectional view of a partially formed flanged connector;

FIGURE 21 is a view of a further step in the roll forming of a flanged connector in accordance with the present invention;

FIGURE 22 is a cross-sectional view of a partially formed flanged connector after being worked with the roll forming apparatus shown in FIGURE 21;

FIGURE 23 is a further step in the roll forming process;

FIGURE 24 is a cross-sectional view of the partially formed flanged connector corresponding to FIGURES 9 and 14;

FIGURE 25 is a step in an alternative embodiment of roll forming flange connectors according to the present invention;

FIGURE 26 is a cross-sectional view of a partially formed flanged connector after utilization of the apparatus shown in FIGURE 25;

FIGURE 27 is a further step in the roll forming process of the present invention;

FIGURE 28 is a cross-sectional view of a partially formed flanged connector corresponding to FIGURES 9 and 14;

FIGURES 29-38 illustrate alternative embodiments of flanged connectors constructed in accordance with the present invention;

FIGURES 39-48 illustrate additional flanged connector profiles constructed in accordance with the present invention;

FIGURES 49-57 illustrate still further embodiments of flanged connector profiles constructed in accordance with the present invention;

FIGURES 58 illustrates a fragmentary cross-sectional view of an embodiment of a double wall square or rectangular duct structure of the present invention illustrating formed flange connector rings engaged with end portions of double wall duct of square/rectangular cross-section;

FIGURES 59-71 illustrate further embodiments of flanged connector profiles for double wall square/rectangular ducting constructed in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGURE 9 illustrates a HVAC duct structure 50 constructed in accordance with the present invention. The structure 50 includes a length of ducting 52 constructed in accordance with the present invention and a formed flanged connector ring 54 also constructed in accordance with the present invention and illustrated as affixed to the adjacent end of the ducting.

Next, referring to FIGURES 4-6, one method of manufacturing the duct 52 is illustrated. In accordance with the present invention, round cross-sectional ducting 51 is

first prefabricated. Preferably, the preformed duct 51 is in the form of a spiral-seam tube composed of a helically wound sheet metal strip, with the strip edges interconnected to each other by formed lock seams. This is a standard, well-known method of manufacturing round ducting from a continuous sheet metal strip. In this regard, see for example, U.S. Patent Nos. 3,263,321 and 3,474,514, which are incorporated herein by reference.

The round, preformed ducting 51 is placed over an expansion apparatus 56 which extends lengthwise within the interior of the round duct. The apparatus 56 includes a pair of spaced apart die structures 58, each having an outwardly directed, substantially flat face 60 and upper and lower edge sections 62 and 64 extending transversely from the face. The die structures 58 may be pushed apart from each other by linear actuators 68 so that the outward faces 60 thereof move in the direction of the arrows 66 shown in FIGURE 5 while maintaining a parallel relationship to each other. As the die structures move outwardly, they cause the round duct 51 to press against the outward faces 60 and also to press against the upper and lower die edges 62 and 64, thereby to transform the round duct 51 into a rectangular cross section duct 52, shown in FIGURE 6. Thereafter, the linear actuators 68 may be activated to retract the die structures 58 to their initial position shown in FIGURE 5 so that the formed duct 52 can be removed.

The linear actuators 68 may be of various types and configurations, including, for example, hydraulic cylinders, pneumatic cylinders, etc. Moreover, guideways or guide structures may be employed to assist in maintaining the die outward faces 60 parallel to each other, especially when being extended outwardly in the direction of arrows 66.

FIGURES 7 and 8 illustrate an alternative embodiment of expansion apparatus 56 wherein the die structures 58' have rounded corners 70 in place of the sharp corners of die structure 58. The components of expansion apparatus 56' that correspond to those components of expansion apparatus 56 are designated with the same part number but with a prime ("'") designation. As shown in FIGURE 8, the use of expansion apparatus 56' results in a duct 52' having rounded corners rather than relatively sharp corners of the

duct 52 shown in FIGURE 6. The rounded corners are thought to provide more efficient airflow through the duct.

It will be appreciated that expansion apparatus 56 and 56' can be utilized to form a square cross-sectional shapes and/or rectangular cross-sectional shapes of various sizes depending on the extent to which the die structures 58/58' are expanded. Also, round pre-form ducting which is longer than the length of the die structure 58/58' may be formed by first transforming one end of the round ducting 51 and then removing the partially formed ducting from the expansion apparatus and inserting it over the die structures 58/58' in a reverse direction, to transform the opposite end of the ducting 51 into the desired cross-section.

Other methods could be utilized to form duct 52/52' in addition to expansion apparatus 56 and 56'. In this regard, an expansion mandrel could be pulled through the round preformed ducting 51. Lengthwise, such expansion mandrel could be circular at a first end having a diameter somewhat smaller than the inside diameter of the preformed ducting 51. From the first end the expansion mandrel could progressively transform from a rounded to a square or rectangular shape of the desired final cross-section of ducting 52. One possible advantage of such an expansion mandrel is that it could be utilized with virtually any length of round preformed ducting 51.

Next, methods for making flanged connector ring 54 will be described. Initially referring to FIGURE 10, the one piece connector ring 54 may be manufactured from a length of strip stock/material 71 having notches 72 stamped or otherwise cut out of its ends as well as intermediate notches 74 stamped or otherwise cut out along the length of strip stock 71. Alignment holes 76, as discussed more fully below, may also be stamped, punched or otherwise cut out of the strip stock 71. The intermediate notches 74 are located at what will become the corners of the flanged connector ring 54, and the ends of the strip stock will form the fourth corner of the flanged connector ring, as discussed below. The intermediate notches 74 preferably do not "break out" to the edge of the strip stock. Rather, a thin section 78 of strip stock is retained, which will assist in forming the

strip stock into a desired profile with less distortion, as discussed below. Each of the intermediate notches 74 includes a rectangular/square portion adjacent thin section 78 and a triangular section opposite thin section 78. The apex of such triangular section corresponds to the center of a corner 80 of the flanged connector ring 54.

The flat strip stock 71 is then formed into a desired profile using rolling and/or bending and/or other well-known techniques. One profile for the connector ring 54 is shown in FIGURE 9. This profile corresponds to FIGURE 15, which illustrates a cross-sectional view of the connector ring shown in FIGURE 9.

The flanged connector ring 54 can be manufactured by first bending or rolling the strip stock 71 lengthwise into an angle shape, as shown in FIGURE 19, with a brake press or with rollers as is well known in the art. The vertical leg of the angle shape shown in FIGURE 19 corresponds to the insertion section 82, of the formed connector 54, see FIGURES 9 and 15. Thereafter, the horizontal leg of the now angle-shaped strip stock 71 is further formed by a first roller set 84, consisting of a first roller assembly 86, having a major diameter roller 88, and a side-by-side smaller roller 90, mounted on a rotatable shaft 92. The first roller set 84 also includes a second roller assembly 94 consisting of a roller 96, mounted on a rotatable shaft 98. The rotatable shafts 92 and 98 may be moved towards and away from each other in a substantially parallel orientation in a well-known manner. When the shafts are moved towards each other, the roller 96, while positioned at the side of the roller 88, turns a portion of the horizontal leg of the preformed strip stock downwardly to partially form a reinforcing section 100, thereby also defining the width of the mating face section 102 of the formed connector 54. The reinforcing section 100 is captured between the adjacent face sections of the rollers 88 and 96. In addition, a horizontal segment 104 of the reinforcing section 100 is formed between the outer diameter of roller 96 and the outer diameter of roller 90. The vertically disposed segment of the reinforcing section 100 serves a hem section of the connector 54, and the horizontal segment 104 will be formed to serve as a return section of the connector, as discussed below.

The partially formed flanged connector 54 of FIGURE 20 is placed in a roller set 110 of FIGURE 21 for further processing. The roller set 110 includes a die roller assembly 112 composed of a die roller 114 mounted on a rotatable shaft 116. The die roller 114 has a grove 118 formed around its parameter in a shape of a half "V" composed of a vertical face 120 and a diagonal face 122. The roller set 112 also includes a second roller assembly 124 composed of a cylindrical roller 126 mounted on a rotatable shaft 128. The roller assemblies 114 and 124 are capable of moving towards and away from each other while the rotatable shafts 116 and 128 remain substantially parallel to each other. As shown in FIGURE 21, the partially formed flanged connector 54 from FIGURE 20 is positioned relative to roller 114 so that hem section 106 is adjacent vertical face 120 of roller 114. Thereafter, the roller assemblies 112 and 124 are moved towards each other as the rollers 114 and 126 rotate relate to each other thereby causing the return section 104 to assume the orientation of diagonal roller face 122 relative to roller face 120, as shown in FIGURE 22.

Thereafter, the partially formed flanged connector 54 in the configuration of FIGURE 22 is further formed by a roller set 130 shown in FIGURE 23. The roller set 130 consists of a pair of roller assemblies 132 and 134, each composed of a roller 136 and 138 carried by corresponding rotatable shafts 140 and 142. As shown in FIGURE 23, the hem section 106 and the partially formed return flange 104 are placed between the two rollers 136 and 138, and then the two rollers are moved towards each other while rotating, thereby to pinch the end section and the return section, therebetween so that the return section closely overlies the end section thereby completing the formation of the reinforcing section 100, as well as partially completing the overall formation of the flanged connector 54, as shown in FIGURE 24. The cross-sectional shape of FIGURE 24 corresponds to the view of the partially formed flanged connector shown in FIGURE 13.

FIGURES 25, 26, 27, and 28, illustrate another method of pre-forming flanged connector 54. As illustrated, the insertion section 82 and the mating flange 102, of the

flanged connector, are formed by bending strip stock 71 with the press or with rollers, as described above. Thereafter, the mating flange portion 102, and the material extending outwardly therefrom that will eventually form the hem section 106, and return section 104, of the connector is placed over a roller set 150 to partially form the hem section 106 and return section 104, as shown in FIGURE 26. The roller set 150 includes a first roller assembly 152 consisting of a roller die 154 mounted on a rotatable shaft 156. A "V" shaped groove 158 extends around the circumference of the roller die 154 to match the outer parameter profile of a roller die 160 mounted on a rotatable shaft 162 of roller assembly 164. The roller assemblies 152 and 164 are capable of moving towards and away from each other while their respective shafts 156 and 162, rotate and maintain an orientation substantially parallel to each other. As a consequence, when the outer marginal portion of the mating flange 102 is placed in alignment with groove 158 and then the roller dies 154 and 160 are engaged with each other, they cooperatively form hem section 106 and return section 104 in the orientation shown in FIGURE 26.

Thereafter, the partially formed flanged connector shown in FIGURE 26 is further worked by a roller set 230 shown in FIGURE 27. The roller set 230 corresponds to the roller set 130 shown in FIGURE 23, with the description set forth above with respect to FIGURE 23 applying to FIGURE 27, but with the part numbers increased by 100. Thus, such description will not be repeated. The results of roller set 230 is a partially formed flanged connector 54 as shown in FIGURE 28. The cross-sectional view of FIGURE 28 corresponds to the longitudinal view of the partially formed connector 54 shown in FIGURE 13.

The partially formed flanged connector 54, shown in FIGURE 13, is then bent at the center of notches 74 represented by bend line 75 to form a connector of the shape shown in FIGURE 9. It will be appreciated that due to the notches 74, the rolled strip stock is readily bent at such notches. It may or may not be necessary to utilize a binding jig. The free ends of the formed flanged connector shown in FIGURE 9 are fastened together, such as by welding. Moreover, each of the other three corners of the flanged

connector is composed of a miter-joint. As such it is preferable to close these joints by welding the diagonal intersection 246 of the adjacent mating flange segments 102, as well as the corner intersection 248 of the adjacent segments of the insertion section 82, see FIGURE 9. In this manner, the formed flanged connector constitutes a structurally sound and strong member capable of securely fastening duct structures together in end-to-end relationship. Such duct structures may be aligned with each other through the use of aligning holes 76 shown in FIGURE 9. Also, a gasket, a bead of caulk, or other sealant can be applied to the outward faces of adjacent mating flanges 102 to form an air tight seal therebetween. It will be appreciated that before the flange connector is bent at bend line 75, the thin section 78 between the notches 74 and the edge of the strip stock 72, are cut, snipped, clipped, or otherwise removed.

FIGURES 11 and 12 show alternative configures of strip stock 71, identified as part Nos. 71' and 71". The corresponding components and features of strip stock 71' and 71" are identified by the same part numbers as in strip stock 71, with the addition of the (') or (") designation. Strip stock 71' and 71" differ from each other and from strip stock 71 by the configuration of notches 74, 74', and 74". These different configurations are capable of accommodating different cross-sectional profiles of flanged connectors. Also, notches 74' and 74" are inset further away from the edges of the strip stock 71' and 71" than the location of notch 74 of strip stock 71. This may be desirable to help prevent distortion in the strip stock as it is being formed into the cross-sectional shape showing FIGURES 24 and 28. The strip stock is composed of relatively thin gauge material, typically from 10 to 20 gauge, but can be of other gauge material.

In the foregoing description, the notches 74, 74', and 74", were described as being cut out or make prior to the forming of the forming of the strip stock into the profile shown in FIGURES 24 and 28. However, such notches can be cut out after the desired profile of the flanged connector is formed, as described above by roll forming and/or bending and/or other well-known techniques. This alternative sequence may be desirable if the particular cross-sectional profile of the flange connector would be such that the strip

stock would tend to distort or warp or not otherwise retain the desired shape during forming.

Two of the flanged connectors 54, as shown in FIGURES 9, 24, and 28, are illustrated in face-to-face relationship to each in FIGURE 14. Such flange connectors may be retained in face-to-face relationship to each other by use of fasteners, such as self-threading screws extending through the mating flanges 102. As noted above, a gasket, a bead of caulk, or other material may be interposed between the mating flanges 102 to achieve an airtight seal therebetween. Also, rather than using threaded fasteners, the flanged connectors may be retained together by clips, for example, clips similar to clips 40 shown in FIGURE 2. It can be appreciated, through the present invention, duct structure 50 may be economically manufactured and installed relative to prior art rectangular/square duct structures, including those discussed above.

The flanged connectors 54 correspond to the T24 flange profile standard established by the Sheet Metal and Air-Conditioning Contractors National Association (SMACNA). Moreover, such connectors are capable of achieving a connector rating from E-J under SMACNA standards. The present invention can be utilized to readily produce other cross-sectional profiles for flanged connectors. Several examples of other profiles are illustrated in FIGURES 15-18. In these figures the part numbers corresponding thereto are identified with the same part numbers as in FIGURE 15, but with a letter suffix. As a first example, the flanged connector shown in FIGURE 16 is also considered to correspond to the SMACNA T24 profile, but with the return section 104 outward of the hem section 106 rather than inward as shown in FIGURE 15.

FIGURE 15 illustrates flanged connectors 54B, which are similar to flanged connectors 54 and 54A, but without a return section 104. This profile corresponds to SMACNA profile T24A. FIGURES 17 and 18 depict flange connector profiles 54C and 54D which also can be manufactured in accordance with the present invention. One manner in which the profile shown in FIGURE 17 differs from that shown in FIGURES 15 and 16 is that the insertion portion 82C is offset slightly upwardly at a

location 254, a distance away from mating flange 102C. This offset provides increased structural strength for the insertion flange portion 82C and also serves as an abutment for the end of duct 82C. The insertion flange section 82D, shown in FIGURE 18, is also constructed somewhat differently than in FIGURES 14-17. In this regard, an arcuate, inwardly directed ridge 256 is formed in the insertion flange portion 82D. This ridge can serve as a locator for the end of duct 52 within which the insertion flange is engaged.

FIGURES 29-38 illustrate alternative embodiments of insertion flange 54. These alternative embodiments differ primarily in the configuration of the re-enforcing sections 100E-100N. In these embodiments, like components/features of these flanged connectors are given the same item number as for flanged connector 54, but with the addition of an alphabetic suffix E-N. In each of the flanged connector profiles 54E-54N, the hem section 106E-106N is provided. However, rather than having a return section that is simply folded over on hem section, each of the re-enforcing sections 100E-100N are somewhat different in configuration. For example, in FIGURE 29, the return section 104E actually extends laterally from the distal end of the hem section 106E (downwardly, shown in FIGURE 29) and then is folded over on itself at 258 in the direction facing the mating flange. It is to be understood that the folded over portion 258 could alternatively be folded over to the outside, i.e., away from the mating flange portion 102E.

FIGURES 30-38 illustrate alternative embodiments of the return section 104F-104N. For example in FIGURE 30, the return section 104F is shown as substantially rectangular or square in cross-section. Whereas, in FIGURES 31, 33, 36, and 37, the return sections 104G, 104I, 104L, and 104M, are substantially triangular in shape. In FIGURE 32, the return section 104H is substantially circular. In FIGURE 34, the return flange portion 104J is generally rectilinear in shape. In FIGURE 35, the return flange portion 104K is generally oval, and in FIGURE 38, the return flange portion 104N is generally hook-shaped, substantially in reverse direction to the return section 104K shown in FIGURE 35. It is to be appreciated that embodiments other than those in

FIGURES 29-38 may be utilized for the flanged connector, including the return section of the flanged connector.

FIGURES 39-48 illustrate further alternative embodiments of flanged connectors. The flanged connectors 54O-54X are similar to flange connectors 54E-54N, but with the exception that the hem sections 106O-106X extend diagonally from the distal (outer) portion of corresponding mating flanges 102O-102X, relative to corresponding mating flanges 102E-102N. The hem sections 106O-106X may be disposed at other angles than shown in FIGURES 30-48. In addition, rather than being relatively straight, the hem sections 106O-106X may be curved, arced, or in other shapes.

FIGURES 49-57 illustrate alternative embodiments of flanged connectors, designated as 54Y-54AG. As in flanged connector 54, such alternative flanged connectors each includes an insertion section, a mating flange and a re-enforcing section. These complements of the flanged connector are given the same part numbers as in FIGURES 9, 24, and 28, but with the addition of a corresponding letter suffix.

In the flanged connectors 54Y-54AD shown in FIGURES 49-54, each includes a short hem section 106Y-106AD extending laterally from the distal (outer) edge of the corresponding mating flange 102Y-102AD and then a return section 104Y-104AD that extends downwardly either substantially parallel to the mating flange or diagonally downwardly and away from the mating flange. Also, each of the flanged connectors 54Y-54AD includes a retention leg section 260Y-260AD, respectively. Such retention leg sections may be substantially parallel to the corresponding insertion structures 82Y-82AD, and help serve to capture or retain the duct 52 between the insertion section and the leg section. The distal end of the leg sections, shown in FIGURES 49-52, and 54, is flared away from insertion section 82Y-82AB and 82AD, so as to function as a "lead-in" for the duct 52 when the flanged connector is assembled with the duct.

The flange connectors 54AE, 54AF, and 54AG, as shown in FIGURES 55, 56, and 57, do not have leg section 260. However, in flange connectors 54AE and 54AF, the

insertion sections 82AE and 82AF are offset similar to that shown in FIGURE 17. Also, the distal end portions of the insertion sections 82AE and 82AF extend or flare diagonally toward the hem section to define a "lead in" since in these embodiments the insertion section is actually exterior to the adjacent end portion of the duct 52.

The flanged connector 54AG shown in FIGURE 57 is formed similarly to a T24 profile, about a groove 262 formed in the mating flange 102AG. A bead of caulk or round sealing ring, not shown, or other type of seal, may be placed within the groove 262 to provide an air tight seal when the flanged connector is installed. As shown in FIGURE 57, the end of the duct 52 includes an outwardly directed end flange 264 that overlaps a portion of the mating flange 102. The end flange 264 may be readily formed with a die structure, rollers, or other means known in the art.

It will be appreciated that the connectors described above in addition to interconnecting lengths of square or rectangular ducting, can also be used as stiffeners for duct lengths. Such connectors can be manufactured in sizes to closely and slidably sliceable engage over the duct. Once in place, the connectors can be affixed to the duct wall by any convenient manner, such as with hardware members, for example, threaded screws extending through the insertion sections of the connector and in to the underlying wall of the duct, or by welding.

FIGURE 58 illustrates double wall flanged connectors 510 and 520 constructed in accordance with the present invention. As shown, the connectors 510 and 520 consist of a first larger square or rectangular flanged ring portion 511 and a second smaller square or rectangular flanged ring portion 512 fastened together to form a single square or rectangular double wall flanged connector 510 or 520. The flanged connectors 510 and 520 are then attached to double wall duct 532.

The flanged connectors 510 and 520 are created by the joining of a first outer or larger square or rectangular flanged portion 511 and a second inner or smaller square or rectangular flanged portion 512. The first square or rectangular flanged connector

portion 511 may be composed of ten gauge or greater metallic material of a square or rectangular cross-section consisting of the following:

(a) an outer insertion flange section 503 that is of a sufficient length to connect to the outer wall 530 of a square or rectangular double wall duct 532.

(b) an outer mating flange portion 504 that extends approximately 90° from the outer insertion flange 503. The outer mating flange section 504 defines the first mating phase 507 that contacts a seal 508 when the square or rectangular flange connectors 510, 520 are opposing each other and connecting two sections of double wall duct 532.

(c) an outer hem section 505 that extends outwardly from, and is approximately uniformly spaced away from the outer mating flange section 504. The outer hem section 505 may extend from, the outer mating flange 504 in generally the same direction as the outer insertion flange 503.

(d) an optional outer return hem section 506 that may be formed by folding a portion of the outer hem 505, located distantly from the outer mating flange 504, over on itself. The return hem 509 may be substantially flattened against the outer hem 505 or may be in other configurations as set forth below. Also, the outer hem 505 and return hem 506 may together form various cross-sectional shapes, such as round, oval, elliptical, etc., and thus may have a hollow interior. Rather than being hollow, the interior defined by the round, oval or elliptical cross-sectional shape may be filled with a circular-shaped rod or filler member for additional strength.

The second square or rectangular flanged ring portion 512 may also be composed of ten gauge or greater metallic material square or rectangular cross-section consisting of the following:

(a) an inner insertion flange 513 that is of sufficient length to connect to the inner wall 531 of the double wall square or rectangular duct 532.

(b) inner mating flange 514 that extends approximately 90° from the insertion flange section 513. The inner mating flange section 514 defines second mating

face 517 that contracts the seal 508 when the square or rectangular flange connectors 510, 520 are opposing each other and connecting two sections of double wall duct 532.

(c) an inner hem 515 that is substantially equally spaced from the inner mating flange section 513. The inner hem section 515 extends from the inner mating flange section 514 in the same direction as the inner insertion flange section 513. The inner hem section 515 extends from the inner mating face of sufficient distance to allow connection to the first or outer square/rectangular flanged ring portion 511, yet not so far to interfere with the connection of the outer insertion flange section 503 with the outer wall 530 of the double wall square/rectangular duct 532. The flanged ring connector 510, 520 is completed when the outer flange ring portion 511 is fastened to the inner flanged ring portion 512. The outer flanged ring portion 511 is aligned with the inner flanged ring portion 512 so that the outer mating flange section 504 and the inner mating flange section 514 form a substantially singular plane. A connection may be accomplished by welding, but is not restricted to that method of fastening.

Two sections of double wall ducting 532 may now be connected. The outer insertion flange section 503 is attached to the inner diameter of the outer wall 530 of the square/rectangular double wall duct 532. The inner insertion flange section 513 is attached to the inner square/rectangular wall 531 of the double wall duct 532. The two opposing square/rectangular flange connectors 510, 512 are attached with a seal 508 being trapped between the first and second mating surfaces 507 and 517.

The outer and inner flange portions 511 and 512 may be constructed in the manner described above. In this regard the outer flange portion 511 shown in FIGURE 58 generally corresponds to the flange connector 54A shown in FIGURE 16. Also, the inner flange portion 512 shown in FIGURE 58 generally corresponds to the flange connector 54B shown in FIGURE 15. Such outer and inner flange connector portions 511 and 512 may be interconnected together, for example, by fastening the outer insertion flange 503 to the inner hem section 515 by welding or by use of fasteners or other appropriate means.

FIGURES 59-64 illustrate alternative embodiments of double wall flange connectors for inter-connecting square and rectangular ducting. The embodiments of FIGURES 59-64 are similar to that shown in FIGURE 58, but with different configurations for the inner flanged connector portion. Accordingly, the embodiments of FIGURES 59-64 are designated with part numbers corresponding to FIGURE 58, but with the addition of an alphabetic suffix A-F.

The embodiment of the present invention shown in FIGURE 59 is similar to that as shown in FIGURE 58, but with the inner hem section 515A shown as being substantially shorter than corresponding hem 515 shown in FIGURE 58. The embodiment of the present invention shown in FIGURE 60 differs from FIGURE 58 in that the inner flange portion 512 does not include an inner hem section. The embodiment in FIGURE 61 is similar to that of FIGURE 58, but with the inner mating flange 514C overlapping the outer mating flange 504C. The embodiment of FIGURE 62 is similar to that of FIGURE 61, but with the outer mating flange portion 504D offset to receive the inner mating flange section 504D. The embodiment of the present invention shown in FIGURE 63 illustrates the hem section 515D configured as a circular bead. The embodiment of the present invention as shown in FIGURE 64 includes a return hem section 519.

Further embodiments to the present invention are illustrated in FIGURES 65-71. The double wall flanged connectors shown in these figures are similar to that shown in FIGURE 58, but with the outer flange connector portion being of various configurations. These embodiments are designated with part numbers corresponding to FIGURE 58 but with an alphabetic suffix G-M. As in the embodiment of present invention FIGURE 58, the embodiments shown in FIGURES 59-71 may also be constructed according to the methods described above with respect to FIGURES 1-58.

The embodiment of the present invention shown in FIGURE 65 is similar to the embodiment of the present invention shown in FIGURE 58, but without utilizing an outer insertion flange section. FIGURE 66 depicts an embodiment of the present invention that

is similar to FIGURE 58, but with the insertion flange 503H being rather short so as not to overlap the outer duct 530H, rather the inner hem 514H is attached to the outer duct 530H. The embodiment of the present invention shown in FIGURE 67 does not utilize an outer insertion flange, rather the outer mating face 504I overlaps the inner mating face 514I. In the embodiment of the present invention depicted in FIGURE 63, an outer insertion flange is not utilized, and the outer hem 504J extends diagonally away from the outer perimeter of the outer mating phase 504J. The embodiment of the present invention shown in FIGURE 69 is similar to that shown in FIGURE 68, but with the addition of an outer return hem 506K and with the outer mating flange 504K overlapping the inner mating flange 514K. The embodiment of the present invention shown in FIGURE 70 is similar to that as shown in FIGURE 69, but with the outer hem 504K and return hem 506K replaced by a circular bead section 506L. The embodiment of the present invention shown in FIGURE 71 is similar to that as shown in FIGURE 70, but with the bead section 506L of FIGURE 70 replaced with an inner hem and return 505M and 506M which together form an ovoid shaped beading cross-section.

Moreover, the double wall flange connector of the present invention can be constructed with the outer flange portion of other configurations, for instance as shown in FIGURES 14, 17, 18 and 29-57 illustrated above.

While preferred embodiments of the invention have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention. In this regard, various configurations and cross-sectional profiles for flange connectors of the present invention have been illustrated and described. These various profiles can be manufactured utilizing the methods of the present invention, beginning with a length of strip stock and forming the desired cross-sectional profile in the strip stock using roll forming bending and other well known techniques. Thereafter, the length of formed strip stock is bent into a square or rectangular configuration corresponding to the cross-sectional shape of the single or double wall ducting being connected together. These methods can be used to form

flanged connector rings of other profiles not shown and described herein, for square and rectangular single and double wall ducts.